# American College of Radiology
# ACR Appropriateness Criteria®
# Plexopathy

**Variant 1:** **Brachial plexopathy, acute or chronic, nontraumatic. No known malignancy.**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI brachial plexus without and with IV contrast | 9 | | O |
| MRI brachial plexus without IV contrast | 7 | | O |
| CT neck with IV contrast | 6 | | ☢☢☢ |
| CT neck without IV contrast | 4 | | ☢☢☢ |
| Myelography and post myelography CT cervical spine | 3 | | ☢☢☢☢ |
| CT neck without and with IV contrast | 2 | | ☢☢☢ |
| US neck | 2 | | O |
| FDG-PET/CT whole body | 1 | | ☢☢☢☢ |
| **Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate | | | *Relative Radiation Level |

**Variant 2:** **Lumbosacral plexopathy, acute or chronic, nontraumatic. No known malignancy.**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI lumbosacral plexus without and with IV contrast | 9 | | O |
| MRI lumbosacral plexus without IV contrast | 8 | | O |
| MRI pelvis without and with IV contrast | 8 | This procedure may be complementary to MRI lumbosacral plexus. | O |
| MRI pelvis without IV contrast | 7 | This procedure may be complementary to MRI lumbosacral plexus. | O |
| CT pelvis with IV contrast | 6 | | ☢☢☢ |
| CT pelvis without IV contrast | 4 | | ☢☢☢ |
| Myelography and post myelography CT thoracic and lumbar spine | 2 | | ☢☢☢☢ |
| CT pelvis without and with IV contrast | 1 | | ☢☢☢☢ |
| FDG-PET/CT whole body | 1 | | ☢☢☢☢ |
| **Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate | | | *Relative Radiation Level |

**Variant 3:** **Brachial plexopathy, traumatic (not perinatal).**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI brachial plexus without IV contrast | 9 | | O |
| MRI cervical spine without IV contrast | 8 | This procedure may be complementary to MRI brachial plexus. | O |
| MRI brachial plexus without and with IV contrast | 7 | Contrast is usually not necessary in the setting of traumatic injury. | O |
| MRI cervical spine without and with IV contrast | 6 | | O |
| Myelography and post myelography CT cervical spine | 6 | | ☢☢☢☢ |
| CT neck with IV contrast | 4 | | ☢☢☢ |
| CT neck without IV contrast | 3 | | ☢☢☢ |
| CT neck without and with IV contrast | 1 | | ☢☢☢ |
| **Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate** | | | ***Relative Radiation Level** |

**Variant 4:** **Lumbosacral plexopathy, traumatic.**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI lumbosacral plexus without IV contrast | 8 | | O |
| MRI lumbar spine without IV contrast | 8 | This procedure may be complementary to MRI lumbosacral plexus. | O |
| MRI lumbosacral plexus without and with IV contrast | 6 | | O |
| MRI lumbar spine without and with IV contrast | 6 | | O |
| MRI pelvis without IV contrast | 5 | This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. | O |
| MRI pelvis without and with IV contrast | 5 | This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. | O |
| CT pelvis with IV contrast | 4 | | ☢☢☢ |
| CT pelvis without IV contrast | 4 | | ☢☢☢ |
| Myelography and post myelography CT thoracic and lumbar spine | 3 | | ☢☢☢☢ |
| CT pelvis without and with IV contrast | 1 | | ☢☢☢☢ |
| **Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate** | | | ***Relative Radiation Level** |

**Variant 5:** **Brachial plexopathy, known malignancy or post-treatment syndrome.**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI brachial plexus without and with IV contrast | 9 | | O |
| MRI brachial plexus without IV contrast | 7 | | O |
| FDG-PET/CT whole body | 7 | This procedure is complementary to MRI brachial plexus or is an alternative if the patient cannot have MRI. | ☢☢☢☢ |
| CT neck with IV contrast | 6 | | ☢☢☢ |
| CT neck without IV contrast | 4 | | ☢☢☢ |
| CT neck without and with IV contrast | 2 | | ☢☢☢ |
| **Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate** | | | ***Relative Radiation Level** |

**Variant 6:** **Lumbosacral plexopathy, known malignancy or post-treatment syndrome.**

| Radiologic Procedure | Rating | Comments | RRL* |
|---|---|---|---|
| MRI lumbosacral plexus without and with IV contrast | 9 | | O |
| MRI pelvis without and with IV contrast | 8 | This procedure is complementary to MRI lumbosacral plexus. | O |
| MRI lumbosacral plexus without IV contrast | 7 | | O |
| FDG-PET/CT whole body | 7 | This procedure is complementary to MRI lumbosacral plexus or is used if the patient cannot have MRI. | ☢☢☢☢ |
| MRI pelvis without IV contrast | 6 | | O |
| CT pelvis with IV contrast | 6 | | ☢☢☢ |
| CT pelvis without IV contrast | 4 | | ☢☢☢ |
| CT pelvis without and with IV contrast | 1 | | ☢☢☢☢ |
| **Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate** | | | ***Relative Radiation Level** |

# PLEXOPATHY

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## Summary of Literature Review

### Introduction/Background

Plexopathy describes abnormal neurological symptoms and signs that localize to an anatomically defined network of nerves called a plexus [1,2].

- Brachial plexus: formed from the C5-T1 ventral rami; the nerve roots pass between the anterior and middle scalene muscles with the subclavian artery to form the trunks. Trunks then split into anterior and posterior divisions, form cords, and travel with the subclavian artery and vein within the infraclavicular region. The cords form terminal branches at the lateral margin of the pectoralis minor muscle and continue through the axilla. Individual nerve branches then continue into the arm and forearm.
- Lumbosacral plexus: formed from the L1-L5 ventral rami with contributions from T12 and S1-S4. The lumbar roots emerge from the psoas major muscle, form anterior and posterior divisions, and finally form anterior and posterior branches to innervate the muscles of the anterior and medial thigh.
- Anterior and posterior divisions also arise from the sacral roots and course over the sacral promontory posterolateral to the internal iliac vessels to form branches that innervate the muscles of the gluteal region, lateral and posterior thigh, and lower leg. The largest terminal branch, the sciatic nerve, exits the pelvis through the greater sciatic foramen usually below but sometimes dividing the piriformis muscle [3-5].

Plexopathy may manifest as pain (shoulder and arm, or back and leg) with a neuropathic character, dysesthesia, and/or burning or electric sensation occurring in >1 peripheral nerve distribution [1,2]. Complete plexopathy causes weakness, sensory loss, and flaccid loss of tendon reflexes in regions innervated by nerves in the C5-T1 (brachial) or L1-L4 (lumbar) distribution. Sacral plexopathy causes the same abnormalities in segments L5-S3, resulting in weakness and sensory loss in the gluteal (motor only), peroneal, and tibial nerve territories. The clinical diagnosis is confirmed by electrodiagnostic studies. In contradistinction, pain that radiates in a dermatomal distribution with or without accompanying sensory loss or motor loss and reflecting a spinal nerve root innervation would be considered clinical evidence of radiculopathy. The role of imaging in the setting of radiculopathy is addressed in the ACR Appropriateness Criteria® "Chronic Neck Pain" [6] and the ACR Appropriateness Criteria® "Low Back Pain" [7]. The evaluation of brachial plexopathy due to entrapment is addressed by the ACR Appropriateness Criteria® "Imaging in the Diagnosis of Thoracic Outlet Syndrome" [8]. This Appropriateness Criteria is for the evaluation of plexopathy in adults and does not include evaluation of birth-related trauma.

### Special Imaging Considerations

Magnetic resonance imaging (MRI) is the mainstay of plexus imaging [9-11], providing superior definition of features of intraneural anatomy as well as localizing pathologic lesions in conditions where electrophysiologic and physical findings are nonspecific [1]. Although there are ICD-10 codes specific to brachial and lumbosacral plexus disorders, there are no Current Procedural Terminology (CPT) codes to correspond to the brachial or lumbar plexus directly. In the February 2001 ACR Bulletin (coding questions and answers), the consensus of the Economics Committee on Coding & Nomenclature was that "the choice of the appropriate CPT code for an MRI study of the brachial plexus depends significantly on the clinical indications. For example, an MRI of the chest, focusing on the brachial plexus, is most commonly used in cases of apical lung cancers (Pancoast tumors),

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whereas an MRI of the orbit, face and neck may be used to identify head and neck cancers to the level of the thyroid, including the brachial plexus. In the evaluation of a tumor of the shoulder girdle or axilla, including the brachial plexus region, or in the evaluation of a patient with a brachial plexopathy (a nonspecific symptom related to the nerve itself that might require imaging), an MRI of the upper extremity would be appropriate" [12].

For the purposes of this document, imaging will be characterized as "MRI of the brachial plexus" or "MRI of the lumbosacral plexus," acknowledging the potential variability of ordering practices across institutions. It is important to note that imaging acquisition for the brachial or lumbosacral plexus differs from sequences that would be in a neck, chest, spine, or pelvic MRI. Imaging of the plexus should include orthogonal views through the oblique planes of the plexus, with T1, T2, fat-saturated T2 or short tau inversion recovery, and fat-saturated T1 postcontrast sequences [2,13,14]. Research continues regarding the use and possible advantages of higher field strength [15-17] in regards to spatial resolution and contrast [9], volumetric sequences [18], and neurography techniques [19-22]. Imaging at 1.5T may be beneficial to reduce artifact if metal is present in the area of clinical concern.

**Discussion of Imaging Modalities by Variant**

**Variant 1: Brachial plexopathy, acute or chronic, nontraumatic. No known malignancy.**

**Variant 2: Lumbosacral plexopathy, acute or chronic, nontraumatic. No known malignancy.**

*Magnetic resonance imaging*

Acute-onset and chronic plexopathies may be caused by diverse etiologies such as intrinsic nerve sheath tumors; infectious, autoimmune, hereditary, or idiopathic neuropathies [2], or extrinsic compression by enlarged or adjacent structures. MRI of the brachial plexus and MRI of the lumbar plexus without and with contrast are the most accurate imaging methods to determine whether a mass is intrinsic or extrinsic to a nerve of the plexus [11]. MRI of the neck, chest, cervical spine, lumbar spine, or pelvis may be complementary but should not be considered an alternative to dedicated plexus imaging in this clinical setting. The most common intrinsic plexus tumors are benign nerve sheath neurofibromas and schwannomas. Malignant peripheral nerve sheath tumors account for 14% of the neurogenic tumors and occur more frequently in patients with neurofibromatosis or a history of radiation therapy [23,24]. When the clinical examination does not reveal an etiology for the patient's neuropathy, MRI may identify a focal or diffuse peripheral nerve or plexus structural abnormality, such as in chronic inflammatory demyelinating polyneuropathy [25,26], multifocal motor neuropathy [27], hereditary hypertrophic motor and sensory neuropathies [28,29], and inflammatory pseudotumor [30].

*Computed tomography*

In patients unable to undergo MRI because of implanted devices or other reasons, computed tomography (CT) offers the next highest level of anatomic visualization possible and can characterize local osseous or vascular anatomy and injury as well [31-34].

*Fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)-PET/CT*

Positron emission tomography (PET)/CT is reserved for patients with newly diagnosed malignancy or post-treatment syndrome, addressed in variants 5 and 6 below.

*Ultrasound*

Ultrasound imaging of the brachial or lumbosacral plexus is highly dependent on the skills of the technologist [35-38] and has not gained widespread use for diagnosis of plexopathies. However, it can be useful for image-guided therapy, which is beyond the scope of this topic.

*Myelography and postmyelography CT*

Myelography is not routinely done for the evaluation of nontraumatic plexopathy as it cannot evaluate the plexus directly.

**Variant 3: Brachial plexopathy, traumatic (not perinatal).**

**Variant 4: Lumbosacral plexopathy, traumatic.**

This Appropriateness Criteria is not intended to evaluate plexopathy related to birth trauma.

*Magnetic resonance imaging*

In the setting of adult traumatic injury, noncontrast MRI can help distinguish preganglionic (intraforaminal) from postganglionic (plexus) injury [1,2,39], a distinction critical to treatment planning [40]. MRI also demonstrates the relationship of the intact nerve to post-traumatic lesions such as neuromas and focal or diffuse perineural fibrosis [9]. Given differences in the planes of imaging and field of view, MRI of the brachial plexus is rated separately from an MRI of the cervical spine in this document [2], and MRI of the lumbosacral plexus is rated

separately from an MRI of the lumbar spine or pelvis. Contrast is not usually necessary in the setting of traumatic injury.

*Computed tomography*
In patients unable to undergo MRI because of implanted devices or other reasons, CT offers the next highest level of anatomic visualization possible and can characterize local osseous or vascular anatomy and injury [31-34].

*Myelography and post myelography CT*
CT myelography is an accurate approach to detect traumatic cervical nerve root avulsion and pseudomeningocele [41,42] but cannot evaluate the plexus itself. Lumbar myelography does not evaluate the plexus.

**Variant 5: Brachial plexopathy, known malignancy or post-treatment syndrome.**

**Variant 6: Lumbosacral plexopathy, known malignancy or post-treatment syndrome.**

*Magnetic resonance imaging*
Oncology patients may present with plexopathy at the time of diagnosis. In the setting of extrinsic compression, for example, from an adjacent lung tumor (brachial plexus) or colorectal tumor (lumbosacral plexus), MRI can also determine the site of displaced or compressed nerve fibers prior to any intervention [43-46]. Lymphatic and hematogenous metastases to the structures surrounding the plexus have been reported with a wide variety of primary malignancies [33,47], and tumors can also involve the plexus via perineural invasion. Lymphoma can compress and/or infiltrate the plexus. Other infiltrative lesions of the plexus include soft-tissue tumors such as sarcomas and fibromatosis [47] as well as amyloid. Techniques such as diffusion-weighted imaging [48-51] and diffusion tensor imaging [52-54] remain in the research realm at this time.

Additionally, the development of new plexopathy in the months to years after treatment is concerning for recurrent tumor versus sequelae of prior radiation therapy. MRI features that favor recurrent tumor are nonuniform, diffuse, or focal enlargement of the plexus components or the presence of an eccentric, enhancing mass [55,56]. MRI features that suggest postradiation injury of the brachial plexus are T2 hyperintensity and diffuse, uniform swelling of the plexus nerves within the radiation field. Diffuse, uniform postcontrast enhancement may persist for months to years after radiation treatment [1,56]. Radiation fibrosis often has low signal intensity on T1-weighted and T2-weighted images [57], and this may represent the more common appearance for chronic radiation injury, although a correlation between the time interval following radiation therapy and T2 signal intensity has not been reported. MRI of the neck, chest, cervical spine, lumbar spine, or pelvis may be complementary but should not be considered an alternative to dedicated plexus imaging in this setting.

*FDG-PET/CT*
PET/CT imaging can identify the extent of tumor involvement in the setting of a new cancer diagnosis but provides limited resolution of the plexus. PET/CT can be beneficial to differentiate radiation plexitis from tumor recurrence in patients with new symptoms after having received regional radiation therapy [58,59].

*Computed tomography*
In patients unable to undergo MRI because of implanted devices or other reasons, CT offers the next highest level of anatomic visualization possible and can characterize local osseous or vascular anatomy and injury [31-34].

**Summary of Recommendations**

- MRI is the mainstay of plexus imaging; however, there are no CPT codes to correspond to the brachial or lumbar plexus directly. This assessment lists “MRI of the brachial plexus” or “MRI of the lumbosacral plexus” as independent entities rather than MRI of the neck, chest, spine, or pelvis but acknowledges the potential variability of ordering practices across institutions.
- MRI of the brachial plexus and MRI of the lumbar plexus without and with contrast are the most accurate imaging methods to determine whether a mass is intrinsic or extrinsic to a nerve of the plexus.
- In the setting of adult traumatic injury, noncontrast MRI is the most appropriate imaging study to distinguish preganglionic (intraforaminal) from postganglionic (plexus) injury, a distinction critical to treatment planning.
- In oncologic patients, MRI of the brachial plexus and MRI of the lumbar plexus without and with contrast are the most accurate imaging methods to identify features of tumoral involvement of the plexus as well as recurrent tumor rather than postradiation injury.
- CT is the next highest level of anatomic evaluation for patients unable to undergo MRI because of implanted devices or other reasons.

**Summary of Evidence**

Of the 59 references cited in the *ACR Appropriateness Criteria® Plexopathy* document, all of them are categorized as diagnostic references, including 2 good-quality studies and 16 quality studies that may have design limitations. There are 40 references that may not be useful as primary evidence. One reference is a meta-analysis study.

The 59 references cited in the *ACR Appropriateness Criteria® Plexopathy* document were published from 1987 through 2015.

Although there are references that report on studies with design limitations, 2 good-quality studies provide good evidence.

**Relative Radiation Level Information**

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

| Relative Radiation Level Designations | | |
|---|---|---|
| **Relative Radiation Level*** | **Adult Effective Dose Estimate Range** | **Pediatric Effective Dose Estimate Range** |
| O | 0 mSv | 0 mSv |
| ☢ | <0.1 mSv | <0.03 mSv |
| ☢ ☢ | 0.1-1 mSv | 0.03-0.3 mSv |
| ☢ ☢ ☢ | 1-10 mSv | 0.3-3 mSv |
| ☢ ☢ ☢ ☢ | 10-30 mSv | 3-10 mSv |
| ☢ ☢ ☢ ☢ ☢ | 30-100 mSv | 10-30 mSv |
| *RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies". | | |

**Supporting Documents**

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.